

**PHYTOPLANKTON CONDITIONS
IN THE
NANTICOKE AREA
OF
LAKE ERIE
1975-1978**

September, 1981



Ontario

**Ministry
of the
Environment**

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by

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PREFACE

As part of the on-going study of water quality in the Nanticoke area of Lake Erie phytoplankton samples were collected at several stations from 1975 to 1978. An evaluation of the abundance and changes in seasonal composition of standing stocks of phytoplankton at these locations is related to complementary chemical and physical data for the same period.

The report compares the phytoplankton data to that collected during pre-operational studies conducted from 1969 to 1974. This report, the third of a series includes a fourth year of data to finalize the first ten years of the Nanticoke study.

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SUMMARY

Changes in abundance and seasonal composition of phytoplankton of the Nanticoke area of Lake Erie were evaluated at eleven stations in 1975, at ten stations in 1976 and 1977 and at thirteen stations in 1978. These data were compared to previous data collected from 1969 to 1974. Water clarity, chlorophyll and phosphorus values were also assessed.

Quantitative measurements of phytoplankton were recorded as Areal Standard Units per millilitre (A.S.U. per ml). The mean value of 430 A.S.U./ml for the period 1975 to 1978 is just slightly higher than the mean value of 382 A.S.U./ml for the entire ten year study period. Statistical trend analyses of the phytoplankton data indicates that there is only a small increase ($\approx 4\%$) with time over the ten year period.

Seasonal succession patterns and biomass levels showed fluctuations expressing unimodal, bimodal and even trimodal peaks from station-to-station and year-to-year.

While phytoplankton densities have decreased in the western basin of Lake Erie coincident with decreased phosphorus loadings, there has been a slight increase in phytoplankton densities and only a small decrease in phosphorus concentrations in the Nanticoke and Dunnville area of the eastern basin of Lake Erie.

Temperature data collected from continuous recorders in the Nanticoke area showed that while temperatures frequently exceed 20°C during the summer months each year, they rarely exceed 25°C . There is no indication that the number of days in which the temperature exceeds 25°C is increasing. This would suggest that heated inputs to Long Point Bay are well assimilated and are not affecting the primary productivity of the bay as reflected by the phytoplankton.

INTRODUCTION

As part of the on-going study of water quality in the Nanticoke area of Lake Erie, phytoplankton samples were collected at several stations from 1975 to 1978. This report evaluates the abundance and changes in seasonal composition of standing stocks of phytoplankton at these locations and relates them to complementary chemical and physical data for the same period. It compares the phytoplankton data to that collected during pre-operational studies conducted from 1969 to 1974 and reported by Michalski (1972) and Hopkins (1975).

METHODS

Field Methods

In 1975, samples for phytoplankton analyses were collected at the same nine permanently marked stations (Figure 1) as in previous years. In addition two new stations (1041 and 1042) were established. Samples were collected as one litre composites through the euphotic zone (twice the Secchi disc depth) at stations 112, 501, 648, 810, 994, 1040, 1041 and 1042 and at 1 metre depth at station 518, 1016 and 1041 approximately every two weeks during the ice-free season.

In 1976 and 1977 samples were collected from ten stations. Station 1008 was eliminated due to its proximity to the construction of the Stelco dock. All samples collected for phytoplankton and chlorophyll analyses were collected as euphotic zone composites. In 1978 three new stations (#1085, 1086 and 1087) were added to provide pre-operational data in the vicinity of Centre Creek to which the proposed Stelco effluents will be discharged.

All phytoplankton samples were preserved with Lugol's iodine solution at the time of sampling and transported to the Ministry of the Environment's laboratories in Toronto for analysis.

In addition, samples were collected at all stations for chemical nutrient analyses at 1 metre below the surface and at 1 metre off the bottom at stations 112, 501, 648, 810, 994, 1016 and 1041. At stations 518, 1040 and 1042 chemical samples were collected at mid depth.

Chemical samples were collected on each date to supplement phytoplankton samples. In 1976 samples were collected for total phosphorus, turbidity and chlorophyll on sixteen dates but only eight dates were included in the report by Polak (1977). In 1977 and 1978 samples were collected for these parameters on twelve and eleven dates respectively but only eight dates were included in the chemical reports by Polak (1978a and 1978b). Secchi disc and water temperature measurements were made in the field. In addition, Ontario Hydro operated continuous recorders at various locations and recorded temperature profiles at each of the above mentioned stations each year.

Laboratory Methods

Samples for phytoplankton analyses were concentrated to a final volume of 25 ml using the Utermöhl sedimentation technique. A one ml aliquot of this concentrated sample was examined at 200X magnification to provide taxonomic identifications to the genus level using a Sedgwick Rafter counting chamber in 1975, 1976 and 1977. In 1978 most samples were examined at 600X magnification using a 5 cc. Utermöhl chamber. All results were expressed as Areal Standard Units per millilitre (A.S.U. per ml) as in the previous studies.

All associated chemical analyses were completed at the Ministry of the Environment, Central Laboratory using procedures currently in effect and as described in "Outline of Analytical Methods" (Ministry of the Environment, 1975).

RESULTS AND DISCUSSION

Chemical and limnological data collected during the study period 1975-1978 have been documented in "Nanticoke Water Chemistry" reports (Polak 1977, 1978a, 1978b). The 1978 report is in preparation. Information on water clarity, (Secchi disc readings and turbidity), chlorophyll a and total phosphorus concentrations may be obtained from the Appendices of these reports. A close examination of these data, however, indicate that water clarity was better at the three off-shore stations 112, 501 and 648 than at the near-shore stations each year. Polak (1978b) has found only small year-to-year differences for the above mentioned parameters.

Temperature data were collected by Ontario Hydro during the study period. Continuous recorders were used at twelve locations and vertical temperature profiles were taken at all chemical sampling stations from April to December of each year. Data for maximum monthly mean, maximum daily mean and maximum hourly water temperatures can be obtained from Ontario Hydro reports #78038, 1978a and #78122. 1978b. Data on the total number of days in which water temperatures reached 20°C and 25°C at station 1040 (the tower site, 1 metre depth) are presented in Table 1 and were provided by R. Walker of Ontario Hydro (personal communication).

Standing Stocks of Phytoplankton

Tables 2-5 summarize the standing stocks of phytoplankton in A.S.U. per ml for the years 1975-1978, respectively. Additionally, mean A.S.U. values are provided by station and by date. Mean A.S.U. values at the three off-shore stations continue to be lower than the near-shore stations with the exception of station 518 in 1975 and station 1016 in 1976 and 1977.

Changes in the seasonal development (expressed as A.S.U./ml) and composition of the major taxonomic classes (expressed as per cent) at each station are presented for the years 1975-1978 in figures 3 to 23.

The annual pattern of seasonal succession was basically the same as in previous years with minor variations. In 1975 the diatoms were dominant in the early spring followed by a cryptophycean peak in May and a blue-green peak in June. The summer months were dominated by the green algae with diatoms and greens co-dominating until the winter diatom population took over in December. There was no blue-green pulse at station 1040 in June, and no late summer blue-green pulse at any station. The dominance by the Chlorophyceae (green algae) in late November was an unusual occurrence for Nanticoke.

In 1976 the seasonal pattern started with diatoms followed by the Cryptophyceae in May and the Chrysophyceae in late June and early July. The biomass was extremely low (i.e. less than 100 a.s.u./ml) while the chrysophycean algae dominated. In July, the cryptophycean Cryptomonas

erosa dominated the algal biomass almost to the total exclusion of other algae. August saw a mixture of diatoms, Chlorophyceae and Cyanophyceae followed by an alternating pattern of Cryptophyceae and diatoms during the fall and into the winter season.

In 1977 when samples were collected tri-weekly, the early spring season was dominated by the Dinophyceae rather than diatoms. A shift from this class to the Chrysophyceae and then Cryptophyceae completed the pattern to mid-summer. In late summer the Chlorophyceae dominated followed by a short blue-green pulse. The fall pattern was similar to previous years with the Cryptophyceae dominating until the onset of winter diatoms.

1978 samples were collected on a tri-weekly basis starting in late April. Diatoms dominated with members of the Cryptophyceae, Chrysophyceae and Dinophyceae all subdominant. There was a distinct shift in dominance by May 15 when Chrysochromulina sp. represented approximately 70% of the population at some stations. In early June a diatom pulse caused by Fragilaria spp. was evident. By late June there was an equally mixed population of Cryptomonas, Fragilaria and unidentified chrysomonads present. In July, Cryptomonas erosa appeared as the single dominant form at all stations with Rhodomonas, and members of the greens and diatoms present as secondary forms. By August the greens were the most important algae present, with Scenedesmus dominating at all stations. By the end of August, while the green algae still dominated as a group, a single blue-green genus Aphanothece sp. presented the highest biomass. The green algae continued to be an important component of the population in mid-September when Oocystis was present at eleven of the thirteen stations with blue-greens and diatoms being of secondary importance. On the two sampling dates in October, the diatoms Fragilaria and Stephanodiscus dominated with the cryptophycean alga Rhodomonas minuta appearing as the sub-dominant form. In December the diatom, Stephanodiscus was the single dominant form at ten stations with Cryptomonas being co-dominant or subdominant at most stations.

In the previous two reports on "Phytoplankton Conditions in the Nanticoke Area of Lake Erie" (Michalski, 1972; Hopkins, 1975) emphasis was placed on a comparison of on-shore versus off-shore conditions related to chemical and biological parameters. While the off-shore stations do show slightly better water clarity and lower algal biomass, the entire Long Point Bay has shown a spatial homogeneity throughout the entire ten years of study. In the last four years (1975 to 1978) covered by this report only the 1978 data showed an increase in phytoplankton biomass. There continues to be a good deal of year-to-year variability in mean phytoplankton biomass but the fluctuations in the annual means for all stations follow a similar pattern from 1969 to 1978 (Figure 2). Data from the Dunnville Regional Water Supply located in the eastern basin of Lake Erie for the same time period were collected and analysed independently from this study (Hopkins, 1979). These data indicate a continual rise in algal biomass since 1974 with only a slight decrease in 1978.

The lowest annual mean algal value at Nanticoke was recorded in 1969 (220 A.S.U. per ml) and the highest value was recorded in 1978 (635 A.S.U. per ml). However, the previous high of 530 A.S.U. per ml was recorded in 1970 during the second full year of the study (Table 6). Algal biomass values of less than 200 A.S.U. per ml are considered very low and values of less than 500 A.S.U. per ml are considered to be moderately low and representative of meso-oligotrophic conditions.

The temporal bimodal pattern of phytoplankton development in which two definite maximal peaks occurred at the off-shore stations in the 1969-1971 sampling period was less distinct in the second three year period 1972-1974 and was replaced by a mid summer maximum. In the current study period 1975-1978 a late summer or fall peak was observed in 1975 while from 1976 to 1978 some stations, particularly the off-shore stations 112 and 501 showed a bimodal pattern again. The remaining stations showed spring, summer and fall peaks with the greatest peaks usually occurring in the early fall. In 1978 phytoplankton densities were greater at all stations, and a distinct bimodal pattern was observed

with the greatest peak occurring in early June. (See Fig. 3-23).

Of greater significance perhaps, and pointing out the spatial homogeneity of the area was the dominance of a single genus of algae at all stations on specific dates. For example in July, 1976 Cryptomonas represented greater than 80% of the total biomass at nine of the ten stations. In 1978, Chrysochromulina dominated ($\approx 70\%$ of total biomass) at 11 of 13 stations on May 15th. Fragilaria dominated at 12 stations on June 5th and at 13 stations on October 11th. Cryptomonas was present as the dominant alga at all 13 stations on July 17th but on the next sampling date, August 14th, the algal population was dominated at all 13 stations by the green alga Scenedesmus.

Temperature data of approximately 20°C during mid-summer can be considered "normal" for the Nanticoke area and changes of a few degrees over a few days would be unlikely to have important effects on seasonal succession of phytoplankton. However, short periods of increased temperature may promote increases in densities of the resident population and this may account for the higher densities observed in 1978, particularly on June 5th and August 30th. Studies on the benthic algae in the Nanticoke area suggest that the upper limit for growth of Cladophora is about 20°C. Growth of Cladophora is limited by water temperatures exceeding 20°C for longer periods of time (Moore, 1976). Similarly, water temperatures of 25°C may be inhibitory to some algae (McCombie, 1963) and an increase in the length of time that water temperatures exceed 25°C would likely alter the seasonal pattern of phytoplankton development.

To date, temperature studies have been conducted in parallel with the other chemical, physical and biological studies. Water temperature data from the "Tower Site", which is near the heated effluent channel, and temperature data from other routine sampling locations show that there has not been any increase in the number of days with water temperatures exceeding 20°C. Predictably, there has been no significant change in phytoplankton since the beginning of the study.

Nicholls et al. (1977) showed that in the western basin of Lake Erie there has been a 42% reduction in phytoplankton at the Union

Water Treatment Plant between 1971 and 1975. This decline in phytoplankton was coincident with decreased phosphorus loadings, and P concentration in nearshore areas from the Detroit River. However, there has been a 4% per annum increase in phytoplankton at Nanticoke even though the phosphorus loading to the Eastern Basin presumably has been reduced since P removal programmes were introduced in 1971. The mean P concentrations at Nanticoke for the period 1969 to 1978 was 0.019 mg l^{-1} showing a small decline (<2% per annum) for this parameter overtime (Heathcote, 1979). The western basin by comparison is a eutrophic body of water with a ten fold higher algal density, while the Nanticoke area is an oligotrophic area with P concentrations about one half that of the Union area in the western basin of Lake Erie.

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Table 1: Number of days in which water temperature exceeded 20°C and 25°C at various locations and depths, between June 21 and September 21, 1971-1978, Nanticoke Area, Lake Erie. Source: Ontario Hydro, Hydraulic Studies and Development Department.

Location	Depth (m)	Year	Number of days in which Temperature Exceeded	
			20°C	25°C
Peacock Point	2	1971	73	0
	2	1972	-	-
	2	1973	71	16
	2	1974	65	1
	2	1975	81	3
	2	1976	57e	0e
	2	1977	73	0
	2	1978	71	3
Tower Site (Sta. 1040)	0.5	1974	55e	1e
	0.5	1975	86e	15e
	0.5	1976	67	1
	0.5	1977	64	5
	0.5	1978	66e	0e
Tower Site	1.5	1971	67	0
	1.5	1972	-	-
	1.5	1973	67	2
	2	1974	47e	0e
	2	1975	82e	9e
	2	1976	72	1
	2	1977	72	0
	2	1978	65e	0e

e = Records incomplete, some temperatures estimated from nearby measuring locations.

Table 2:

SUMMARY OF PHYTOPLANKTON DATA AT ELEVEN SAMPLING STATIONS IN THE NANTICOKE AREA, LAKE ERIE, 1975. ALL RESULTS ARE EXPRESSED AS AREAL STANDARD UNITS PER ML.

Station	Apr 29	May 13	May 28	June 10	July 8	Aug. 7	Aug. 20	Sept. 3	Sept. 17	Sept. 30	Oct. 22	Oct. 28	Nov. 19	Nov. 24	Mean
112	185	209	403	390	295	378	335	262	568	329	486	377	258	290	340
501	189	263	316	461	204	408	500	1133	566	824	367	424	225	205	435
518	273	303	212	248	184	455	334	287	517	424	532	321	574	247	351
648	174	162	411	272	164	381	467	423	655	312	388	356	509	328	357
810	303	283	271	190	431	350	369	660	652	1133	1060	509	276	253	481
994	429	256	388	482	124	580	927	251	695	409	221	380	295	206	403
1008	470	230	188	590	232	557	-	315	-	281	-	646	-	271	378
1016	178	222	377	296	218	347	517	330	810	275	506	374	302	294	360
1040	292	413	619	203	204	744	338	323	829	997	309	326	323	244	440
1041	-	-	443	-	183	179	461	362	469	276	655	387	287	245	359
1042	-	-	373	-	106	248	-	395	681	176	490	400	583	142	359
MEAN	277	260	364	348	213	421	472	431	644	494	501	409	363	248	

Table 3:
SUMMARY OF PHYTOPLANKTON DATA AT TEN SAMPLING STATIONS IN THE NANTICOKE AREA, LAKE ERIE, 1976. ALL RESULTS ARE EXPRESSED
AS AREAL STANDARD UNITS PER ML.

Station	Apr. 14	Apr. 26	May 12	May 26	June 9	June 22	July 7	July 21	Aug. 3	Aug. 17	Aug. 31	Sept. 15	Sept. 30	Oct. 13	Oct. 26	Nov. 10	Dec. Mean 9
112	270	312		257	64	32	183	268	218	321	289	412	514	126	356	206	199 252
501	151	384		237	79	49	119	199	116	163	389	208	421	491	240	336	276 241
518	355	467		164	65	103	341	502	381	517	599	244	269	344	251	268	459 333
648	393	467		107	135	46	317	290	261	201	957	183	327	102	212	438	187 289
810	297	479		53	70	81	425	332	160	546	705	977	287	84	237	627	186 347
994	595	630		137	81	65	184	343	278	675	2269	160	302	102	805	356	215 450
1016	373	577		55	87	58	510	216	207	262	438	276	283	170	235	284	206 265
1040	414	396		86	57	100	338	280	182	575	471	328	219	173	533	673	229 316
1041	541	307		100	94	107	308	284	132	1107	484	232	390	133	479	421	278 337
1042	956	774		128	67	77	713	363	289	790	889	1473	259	201	245	415	552 512
MEAN	435	479	-	132	80	72	344	308	222	516	749	449	327	193	359	402	279

Table 4:

SUMMARY OF PHYTOPLANKTON DATA AT TEN SAMPLING STATIONS IN THE NANTICOKE AREA, LAKE ERIE, 1977. ALL RESULTS ARE EXPRESSED AS AREAL STANDARD UNITS PER ML.

Station	April 19	May 3	May 24	June 14	July 6	July 26	Aug. 15	Sept. 6	Sept. 29	Oct. 19	Nov. 22	Dec. 8	MEAN
112	944	345	299	396	200	321	337	225	245	469	74	115	331
501	248	294	271	253	99	337	427	282	279	363	231	156	270
518	943	290	192	473	149	234	996	600	1273	332	77	200	480
648	450	421	345	-	195	450	302	373	239	547	90	168	325
810	1092	203	282	278	238	346	-	532	170	495	98	165	354
994	520	302	232	779	253	320	288	585	575	305	247	196	384
1016	347	382	266	247	177	610	418	424	416	414	38	113	321
1040	1205	282	502	185	259	484	448	655	367	1534	112	200	519
1041	1384	321	256	501	194	361	387	557	754	98	200	203	435
1042	1196	719	294	-	217	1014	565	186	314	473	498	178	514
MEAN	833	356	294	389	198	448	463	442	463	503	167	169	

Table 5:

SUMMARY OF PHYTOPLANKTON DATA AT THIRTEEN SAM. LING STATIONS IN THE NANTICOKE AREA, 1978. ALL RESULTS ARE EXPRESSED AS AREAL STANDARD UNITS PER ML.

Station	April 25	May 15	June 5	June 27	July 17	Aug. 14	Aug. 30	Sept. 19	Oct. 11	Oct. 30	Dec. 12	MEAN
112	235	492	642	258	375	560	1390	505	414	500	161	503
501	276	562	1273	450	427	315	1093	481	792	541	298	592
518	277	407	869	542	455	326	916	587	679	437	241	521
648	270	688	627	128	345	586	1719	558	546	431	327	566
810	502	345	1195	371	700	646	1441	435	933	618	684	715
994	323	373	974	471	821	768	842	742	899	657	309	653
1016	416	427	1506	566	571	497	1219	783	524	710	391	692
1040	328	292	1829	595	704	834	964	832	907	826	262	761
1041	333	379	1336	381	502	589	1468	397	435	412	287	593
1042	386	587	1857	388	588	677	882	167	446	799	463	658
1085	371	888	1275	513	1046	379	1066	662	1084	877	533	790
1086	489	399	1852	403	375	602	930	167	693	334	536	616
1087	385	350	1274	261	494	445	1377	455	510	441	503	590
MEAN	353	476	1270	410	569	556	1177	521	652	583	384	

Table 6: Summary of annual mean standing stock of phytoplankton at eleven stations at Nanticoke and at Dunnville, eastern basin, Lake Erie 1969-1978. All value expressed as Areal Standard Units per ml.

Station	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
112	172	445	335	250	386	201	340	252	331	503
501	231	487	518	199	341	192	435	241	270	592
518	245	538	452	254	307	249	351	333	480	521
648	204	516	304	278	466	264	357	288	325	566
810	228	539	332	301	497	233	481	347	354	715
994	320	664	446	324	654	286	403	450	384	653
1008	178	586	381	310	408	254	378	-	-	-
1016	167	478	414	214	334	248	360	265	321	692
1040	-	-	301	312	361	256	440	316	519	761
1041	-	-	-	-	-	-	359	337	435	593
1042	-	-	-	-	-	-	359	512	514	658
1085	-	-	-	-	-	-	-	-	-	790
1086	-	-	-	-	-	-	-	-	-	616
1087	-	-	-	-	-	-	-	-	-	590
All Stations	220	530	387	272	417	242	388	334	393	635
Dunnville	785	563	761	719	699	937	1228	1420	1342	1110

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- Fig. 2. Phytoplankton Biomass - Expressed as A.S.U./ml. Annual mean at eleven locations Nanticoke Area, Lake Erie. 1969-1978. Station "ALL" is the annual mean of all stations each year from 1969-1978.
- Fig. 3 to 23. Seasonal development (as A.S.U./ml) and composition of the major classes (as percent) at each station Nanticoke Area, Lake Erie. 1975-1978.

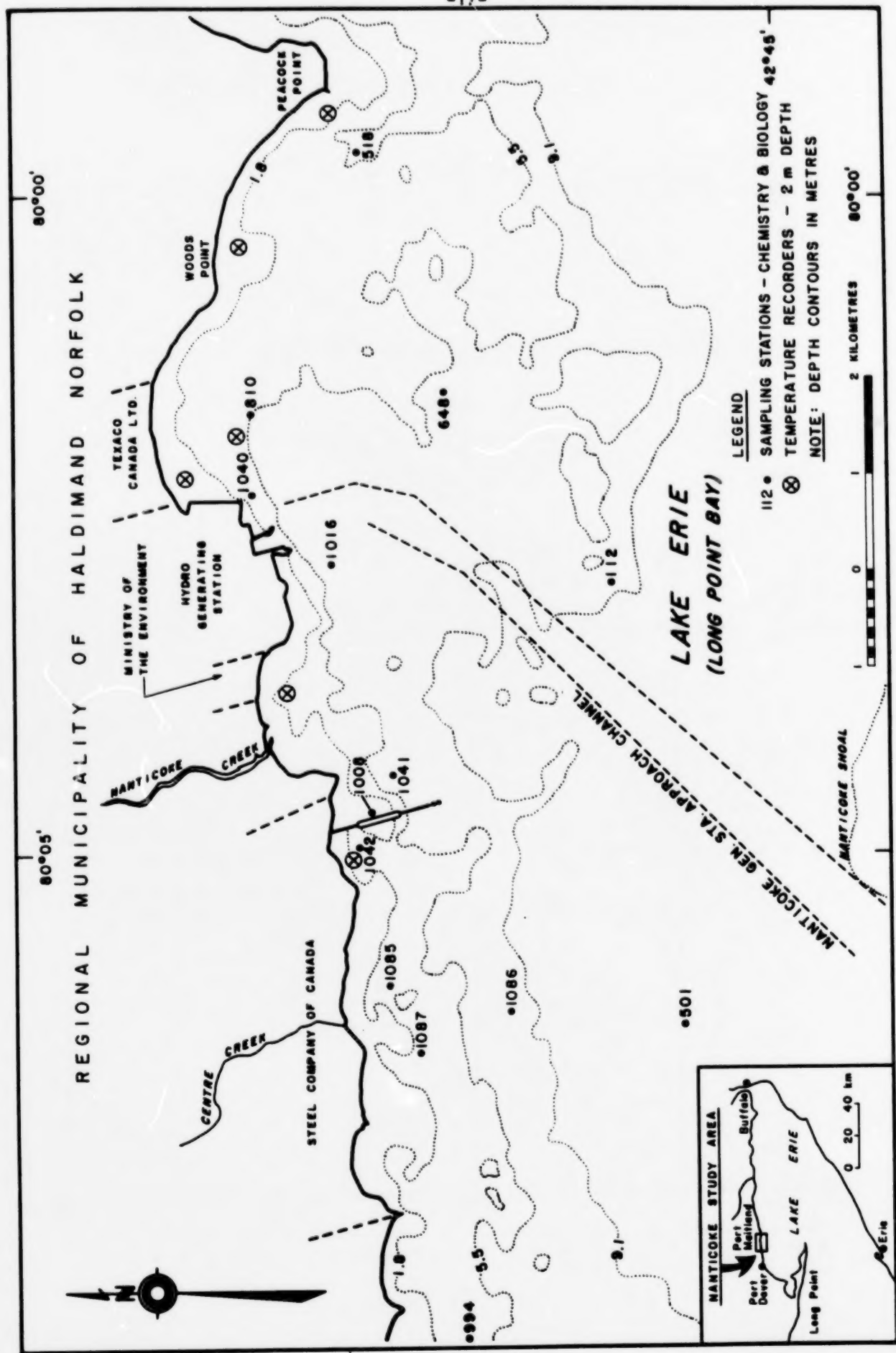


FIGURE 1.

Figure 2:

NANTICKE 1969-1978 PHYTOPLANKTON-ANNUAL MEAN

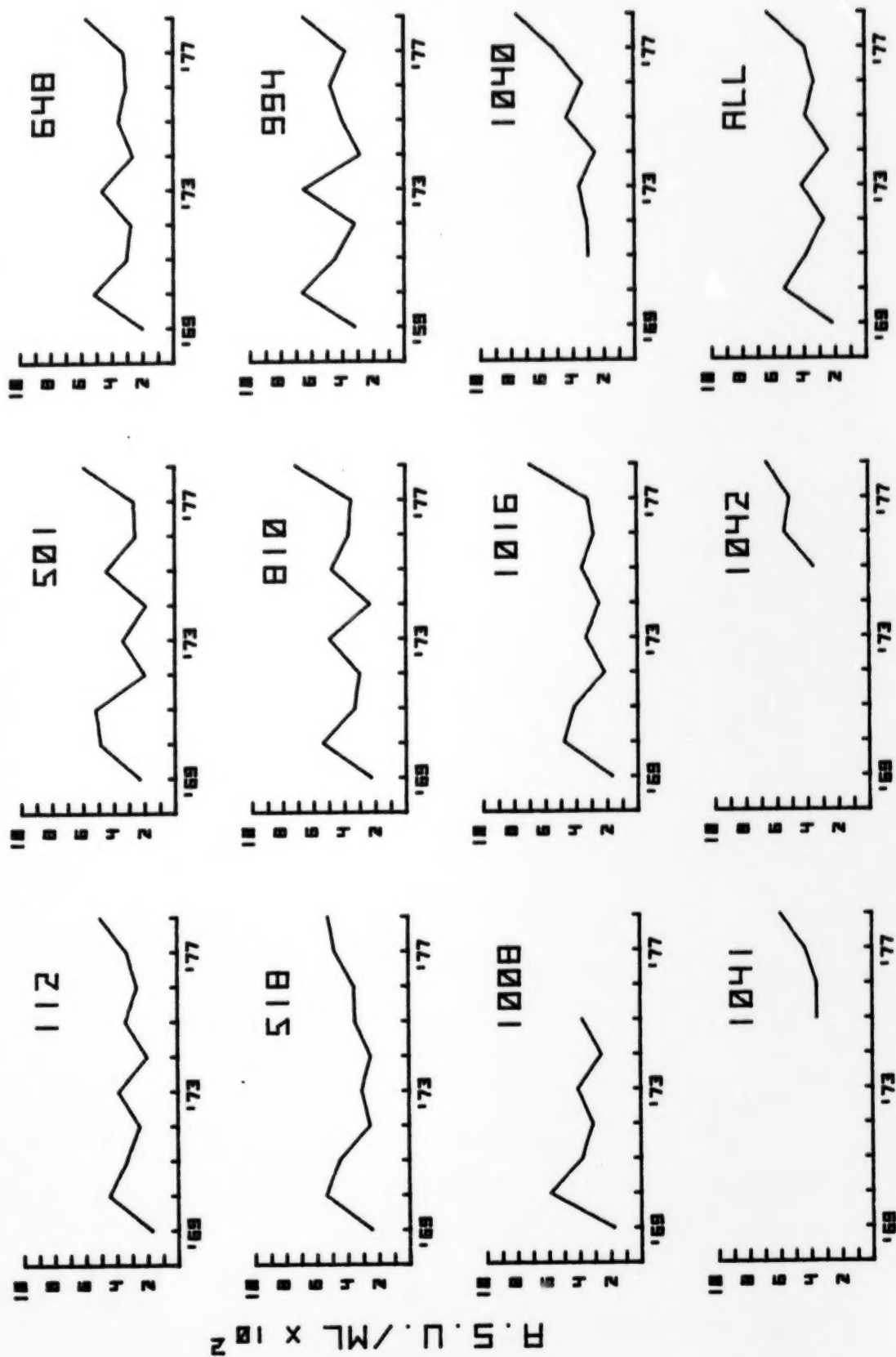


Figure 3:

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NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 112

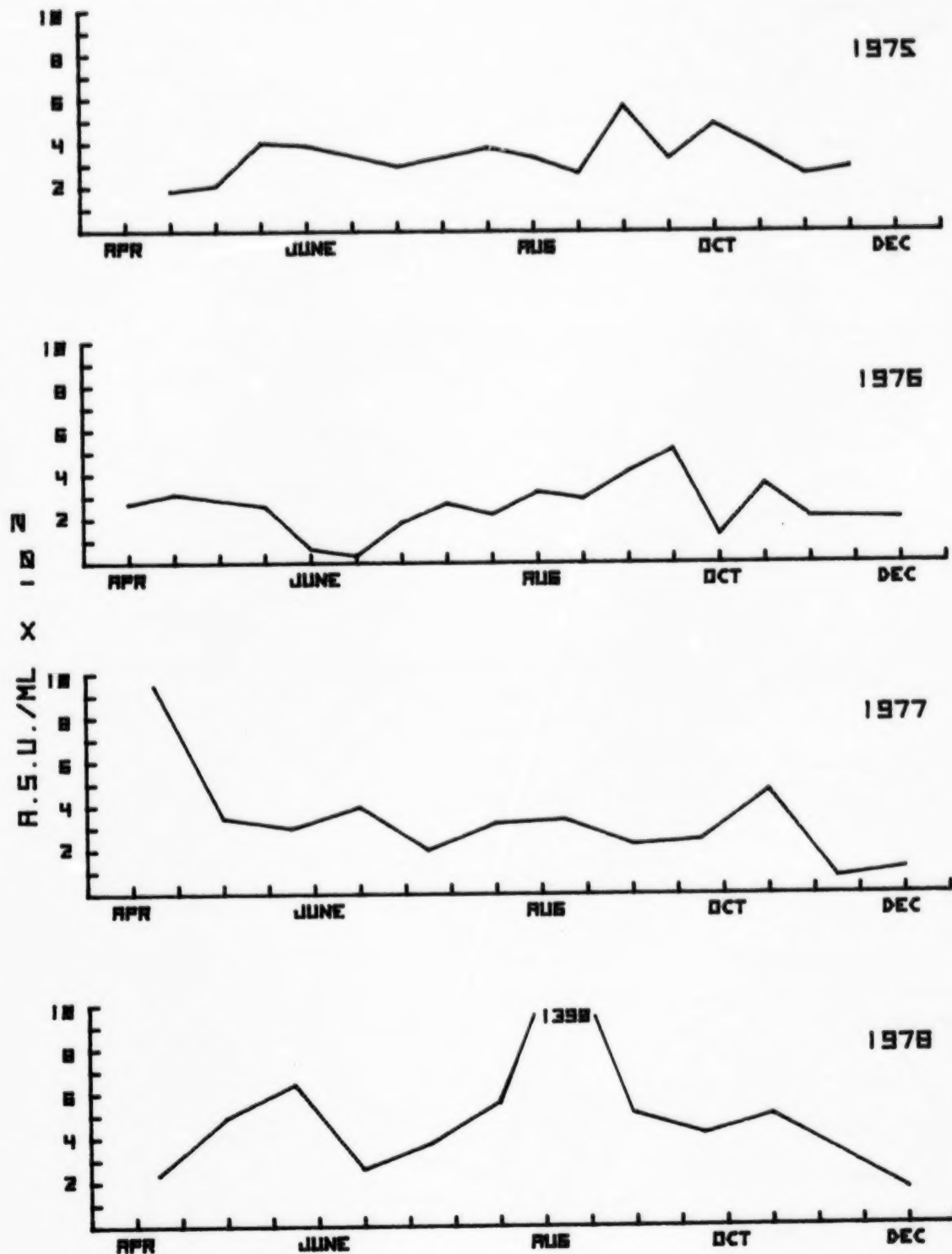


Figure 4:

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NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 112

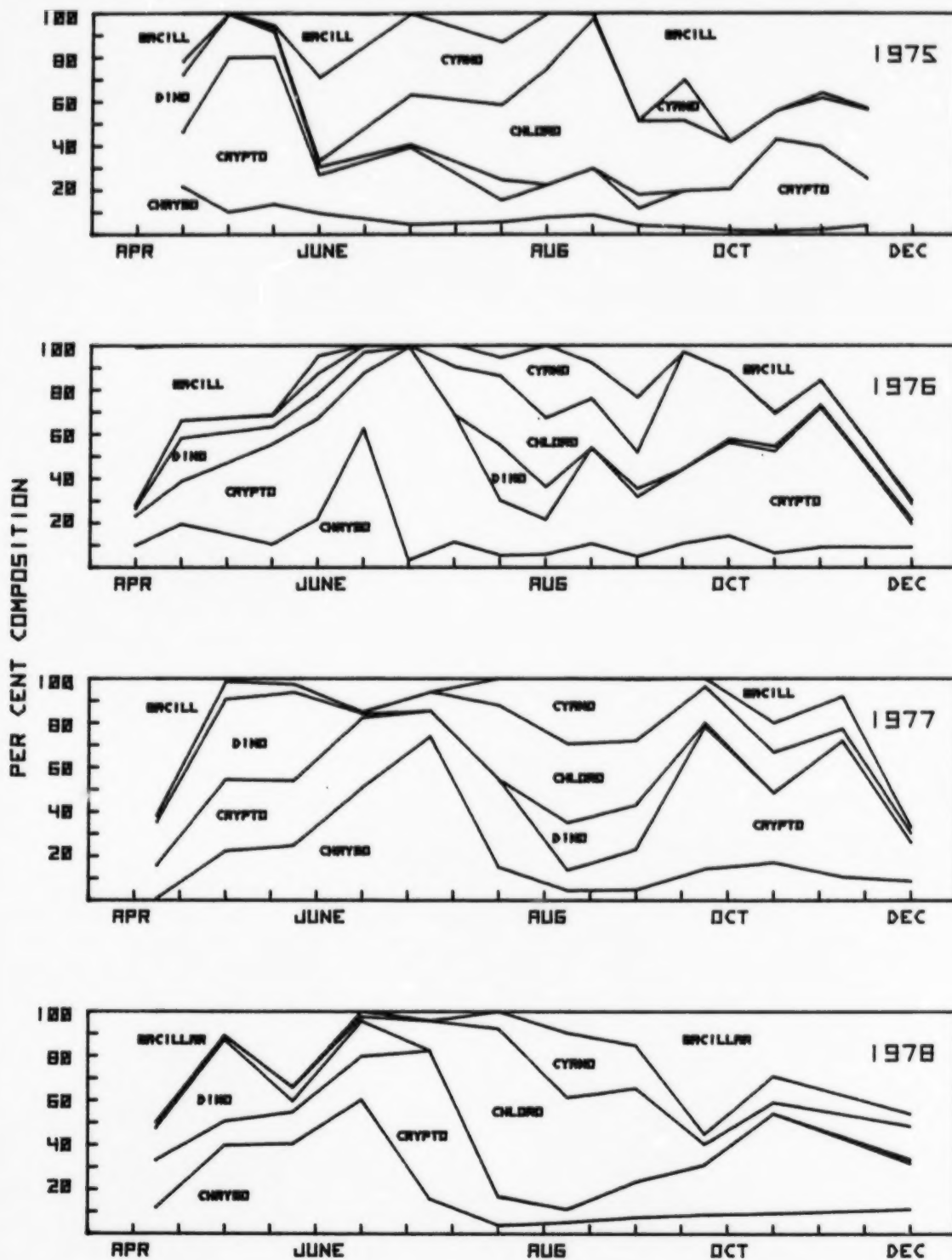


Figure 5:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 501

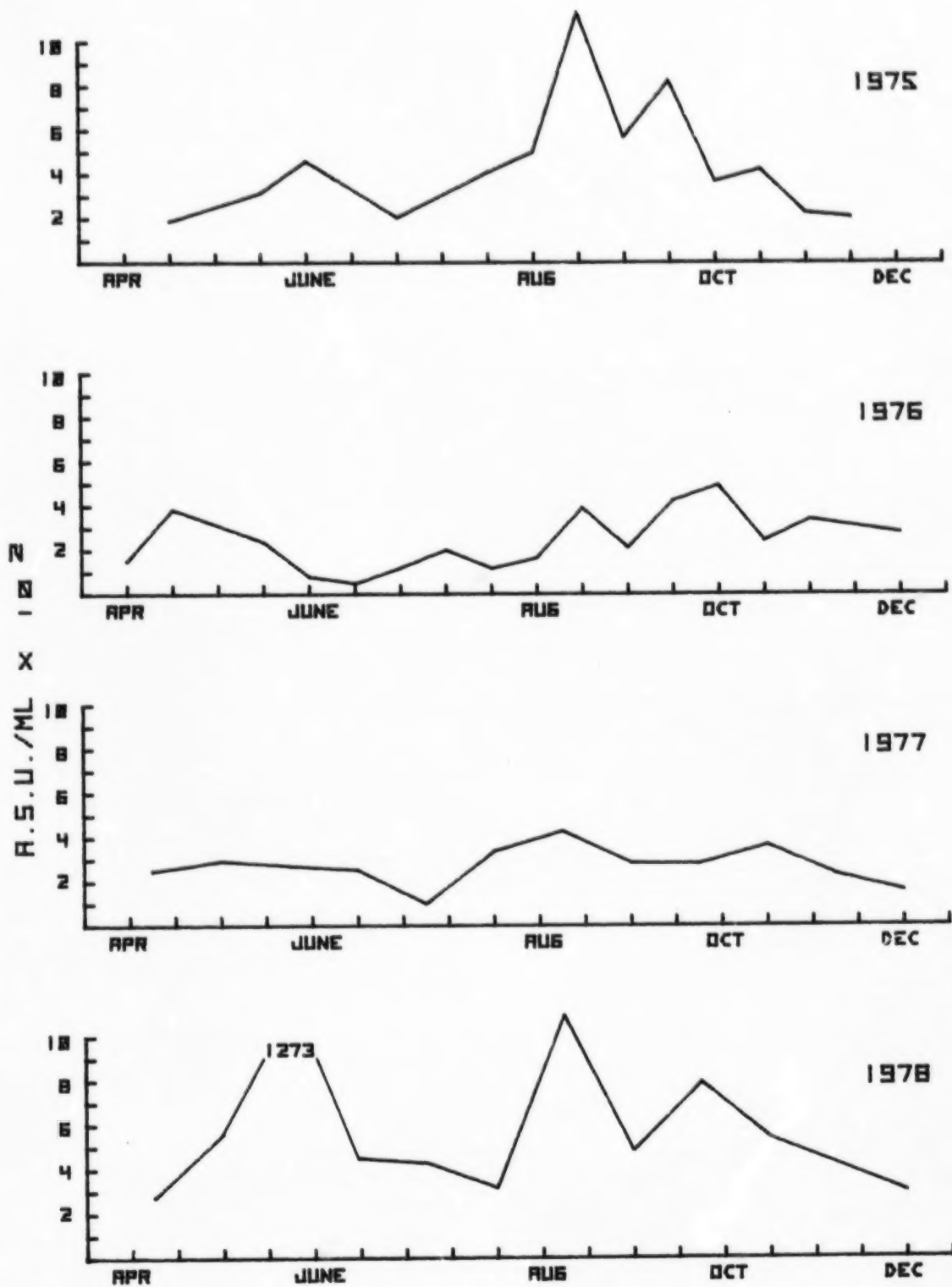


Figure 6:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 501

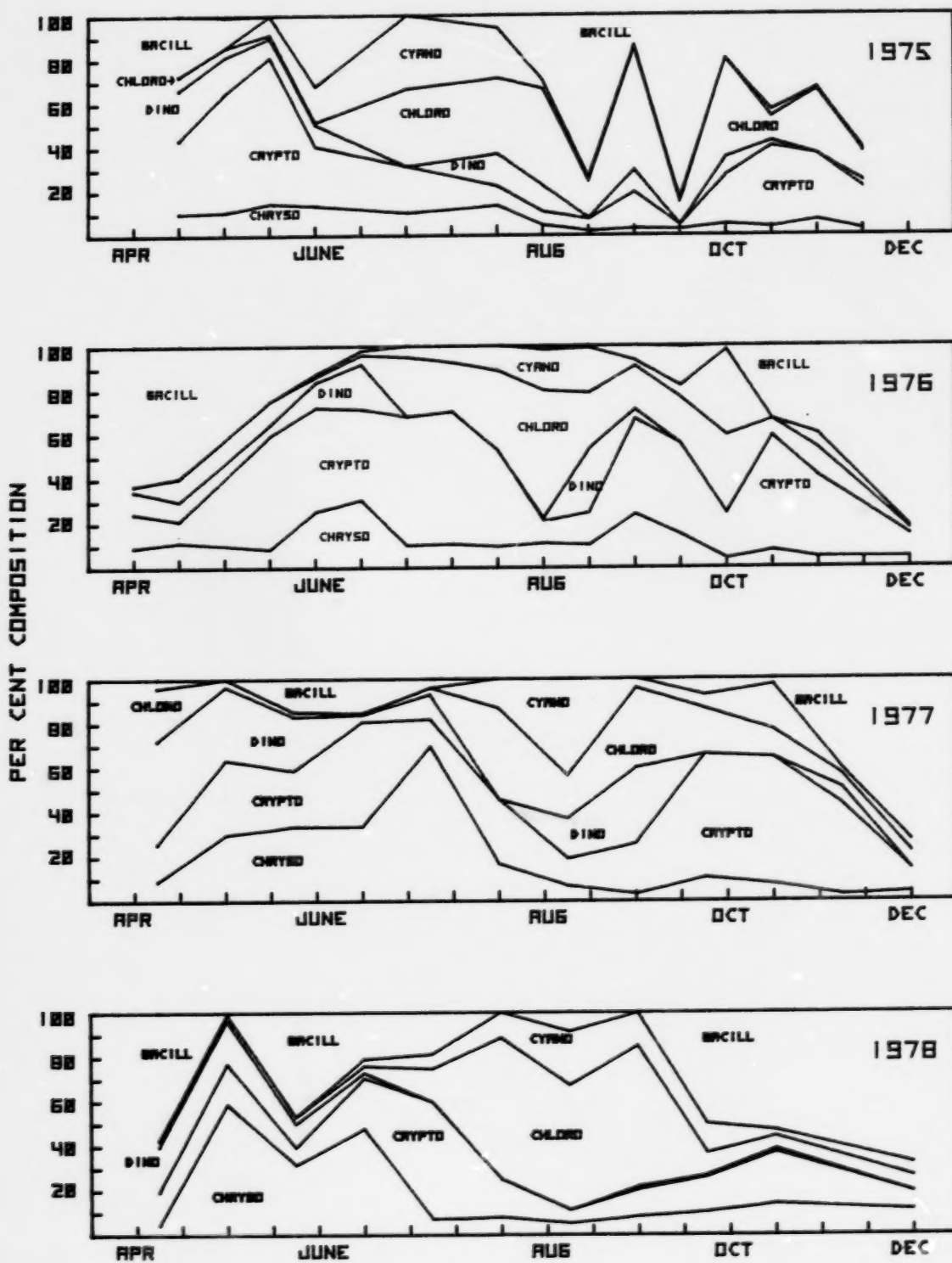


Figure 7:

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NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 518

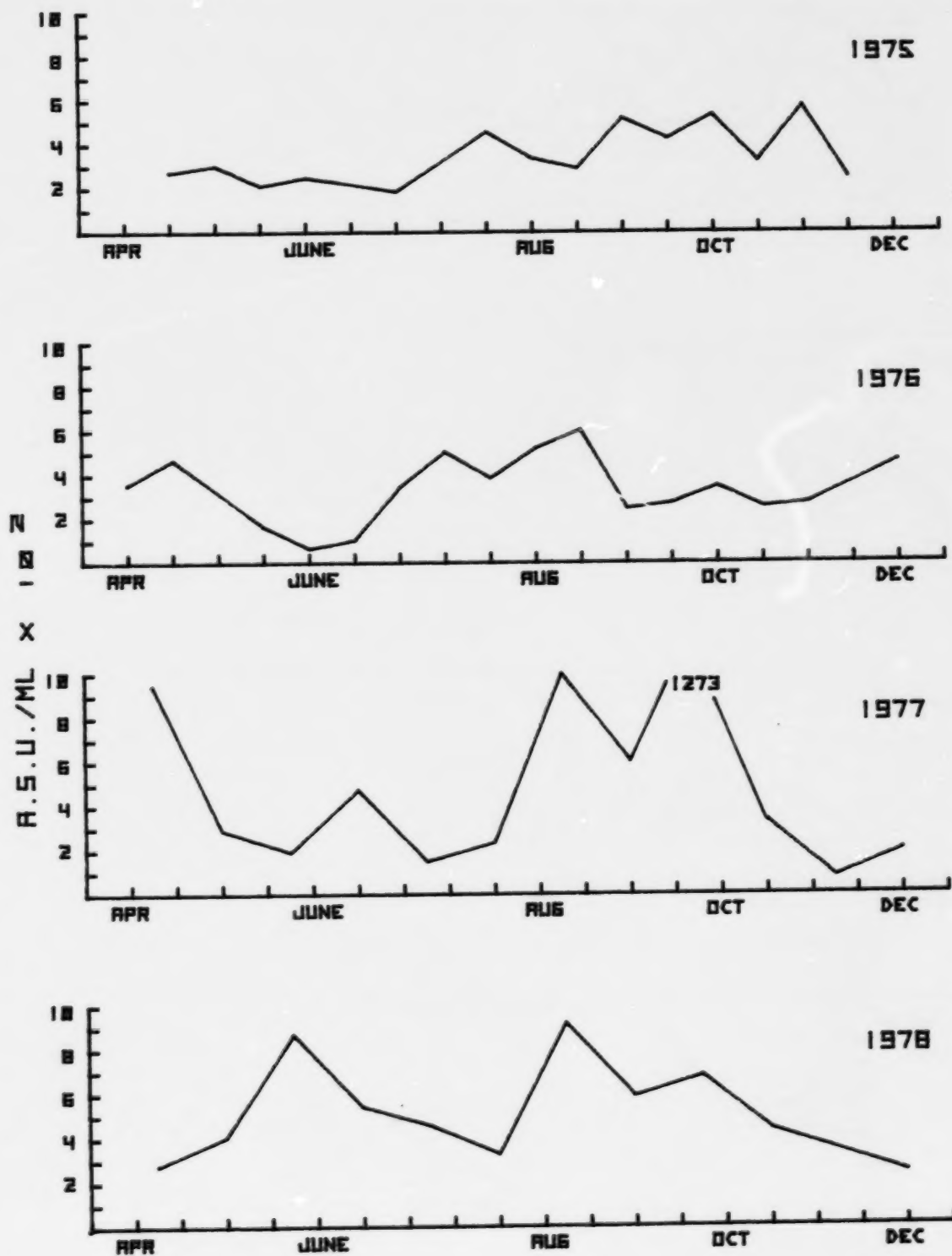


Figure 8:

-24-

NANTICKE PHYTOPLANKTON TOTAL BIOMASS STA. 518

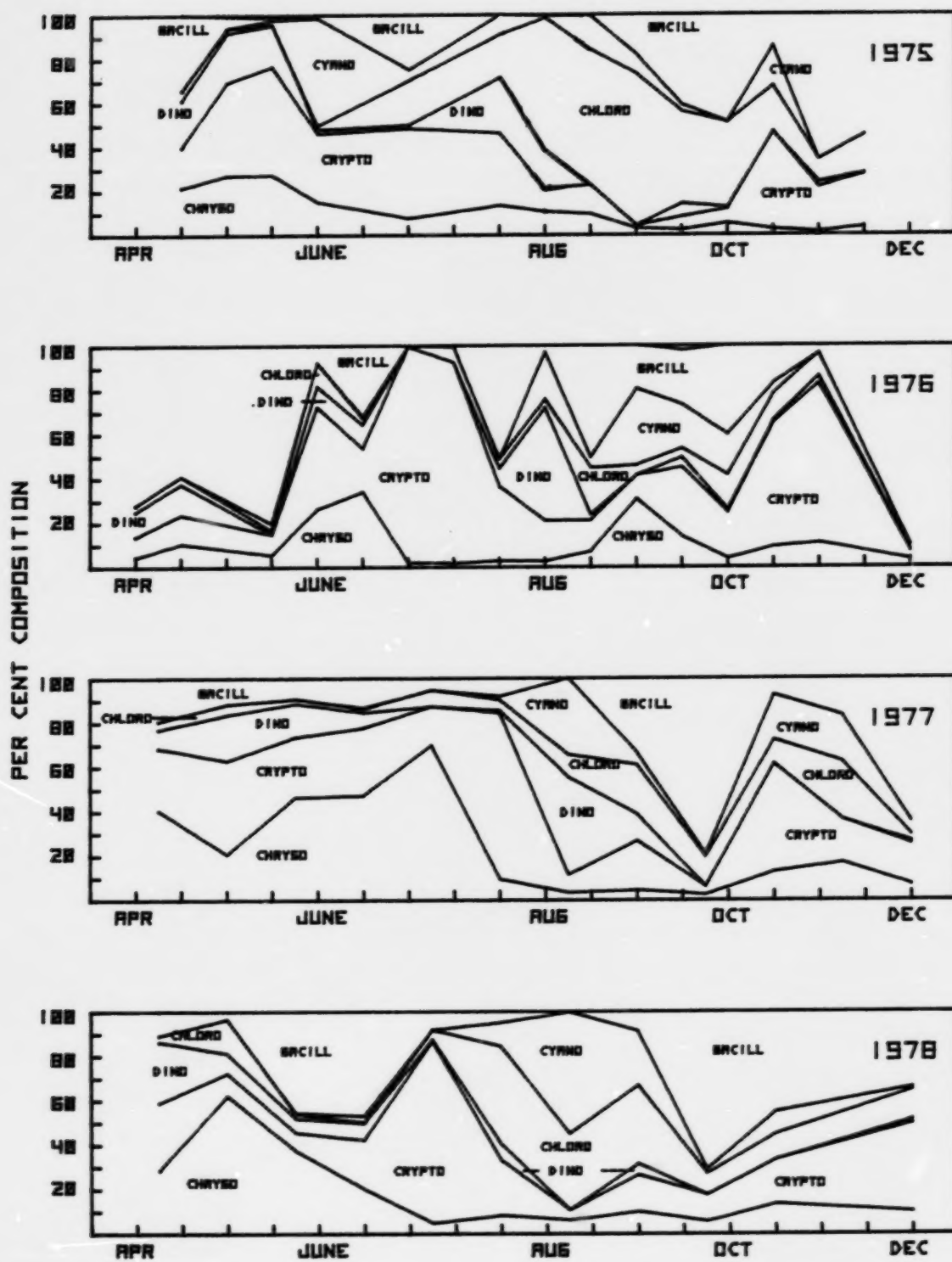


Figure 9:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 648

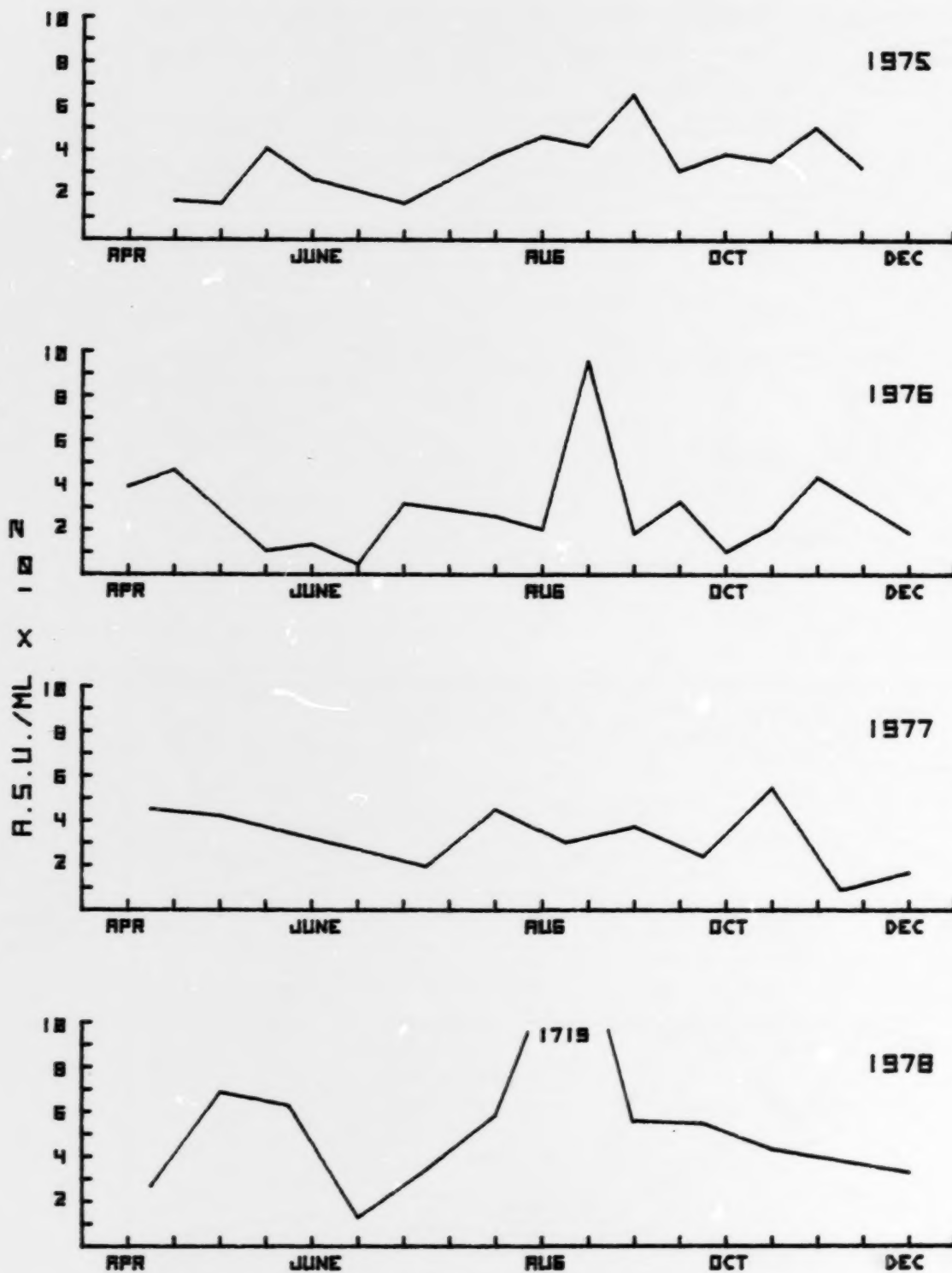


Figure 10:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS

STA. 648

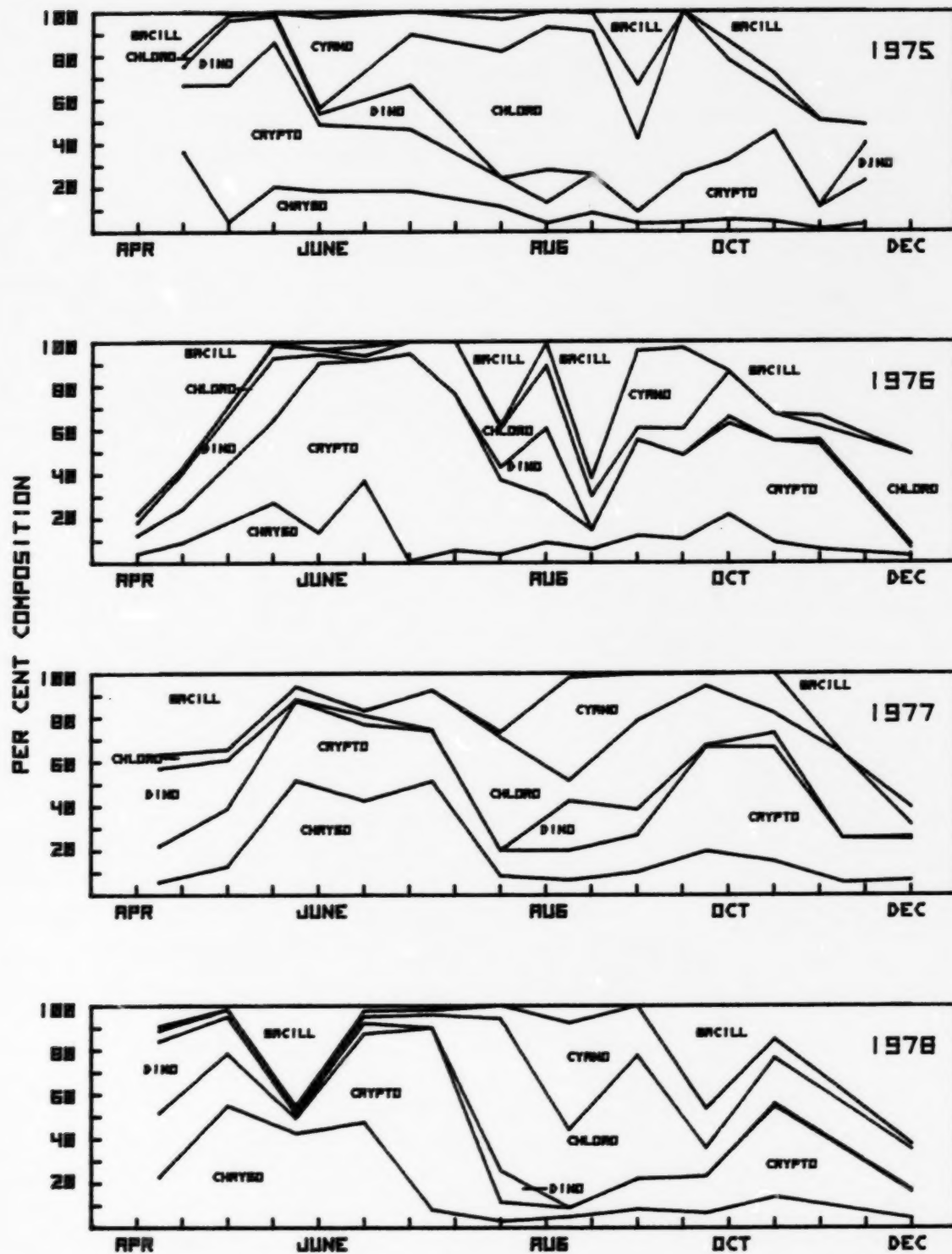


Figure 11:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 810

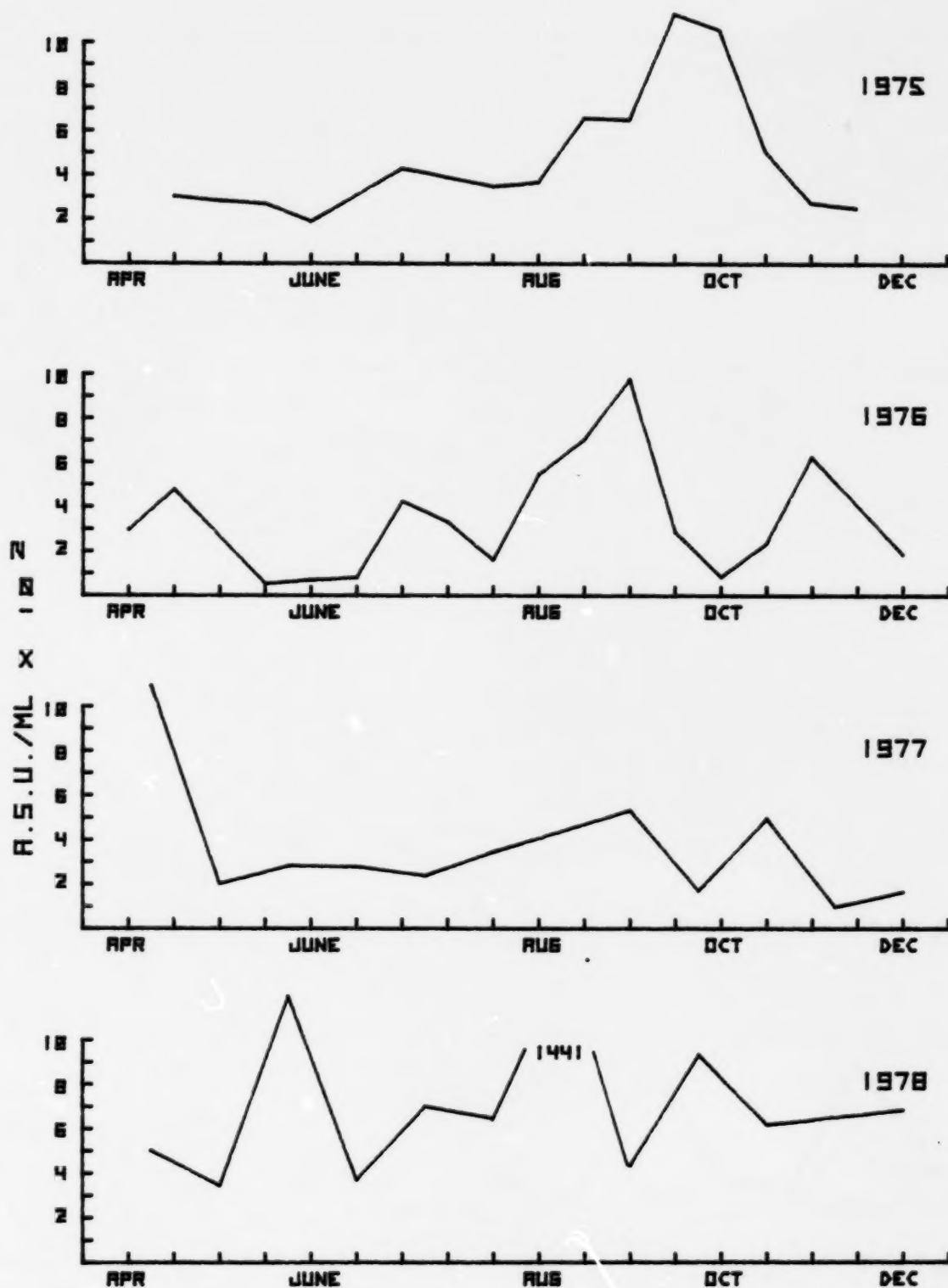


Figure 12:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 810

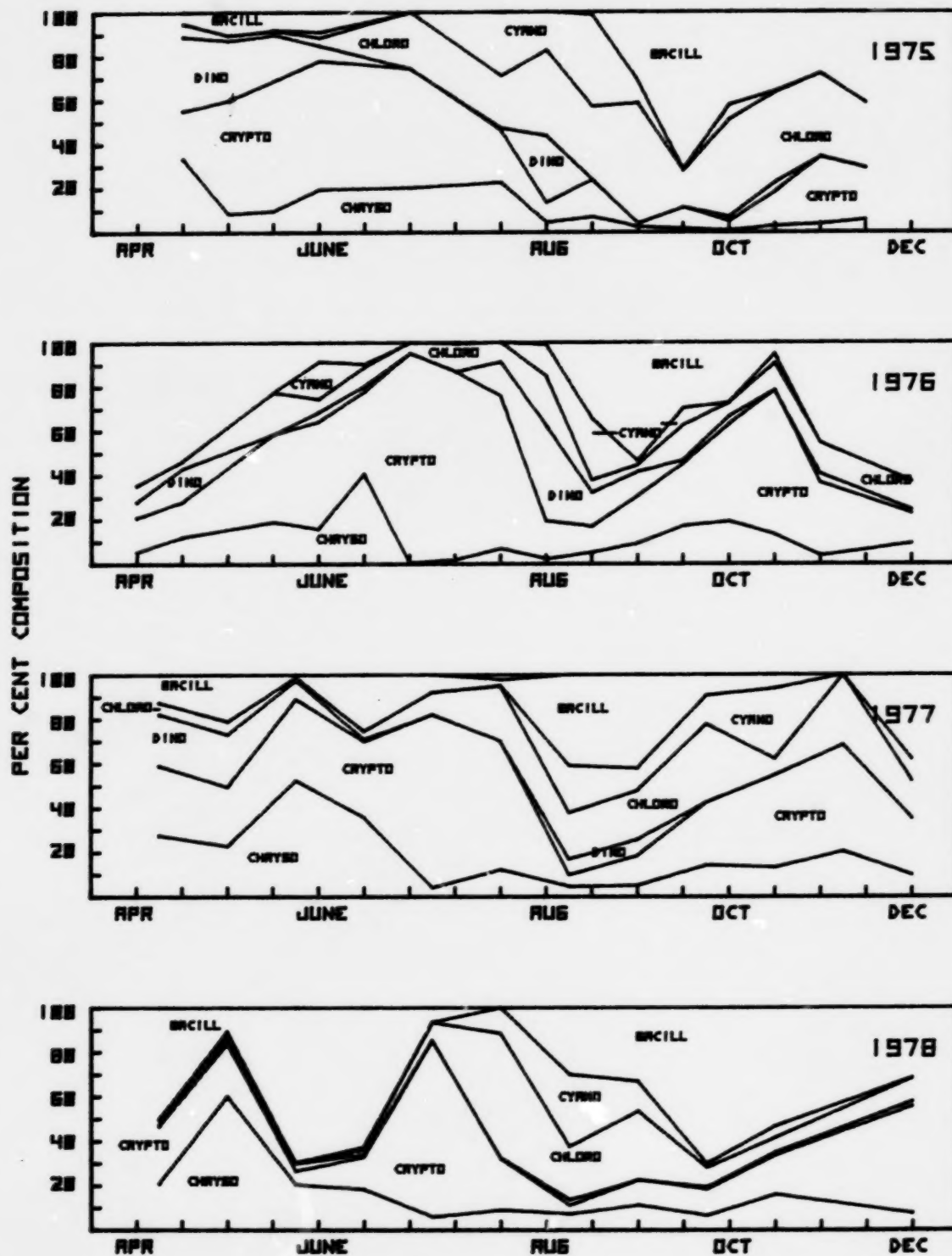


Figure 13:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 994

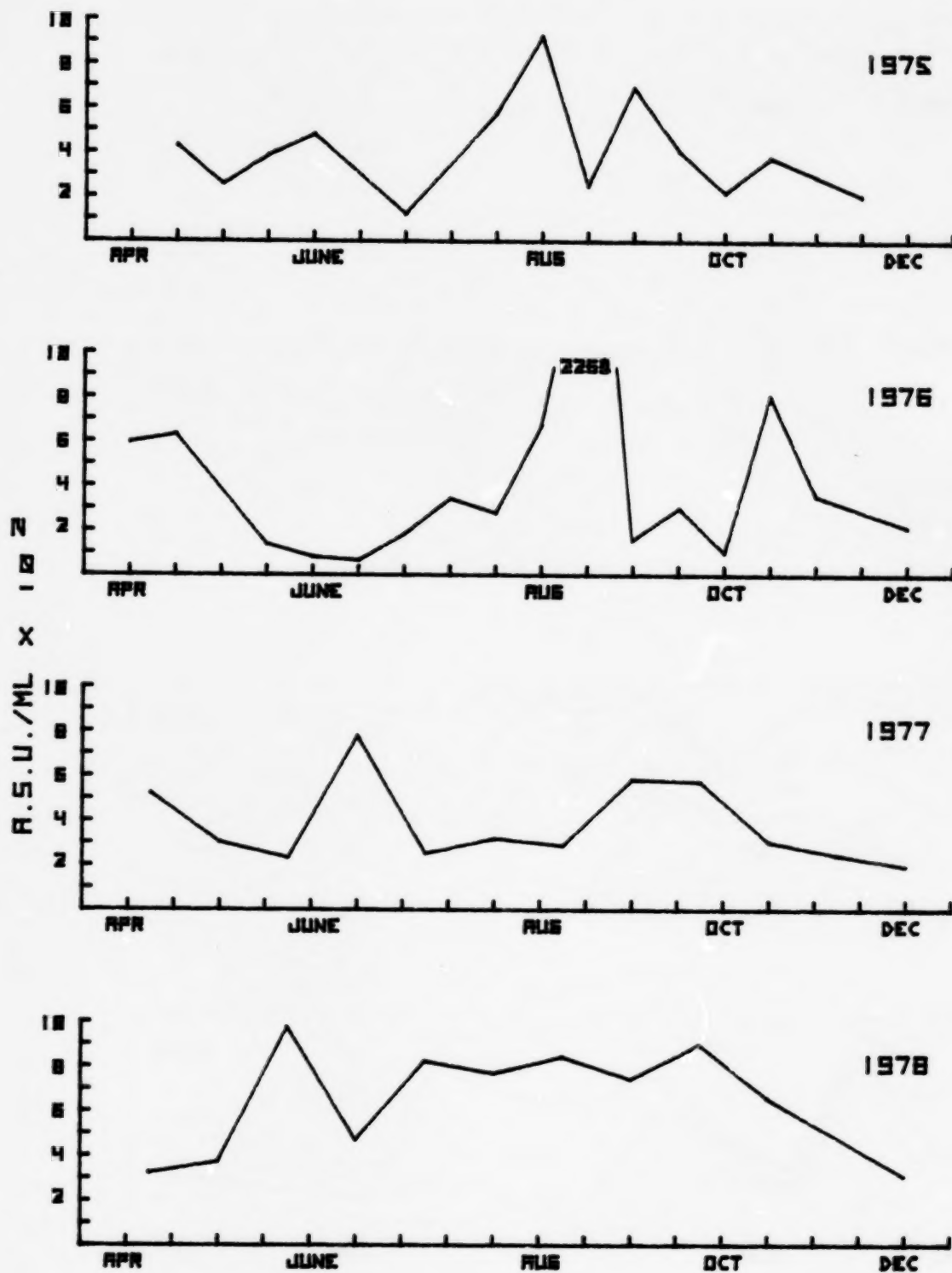


Figure 14:
NANTICKE PHYTOPLANKTON
TOTAL BIOMASS STA. 994

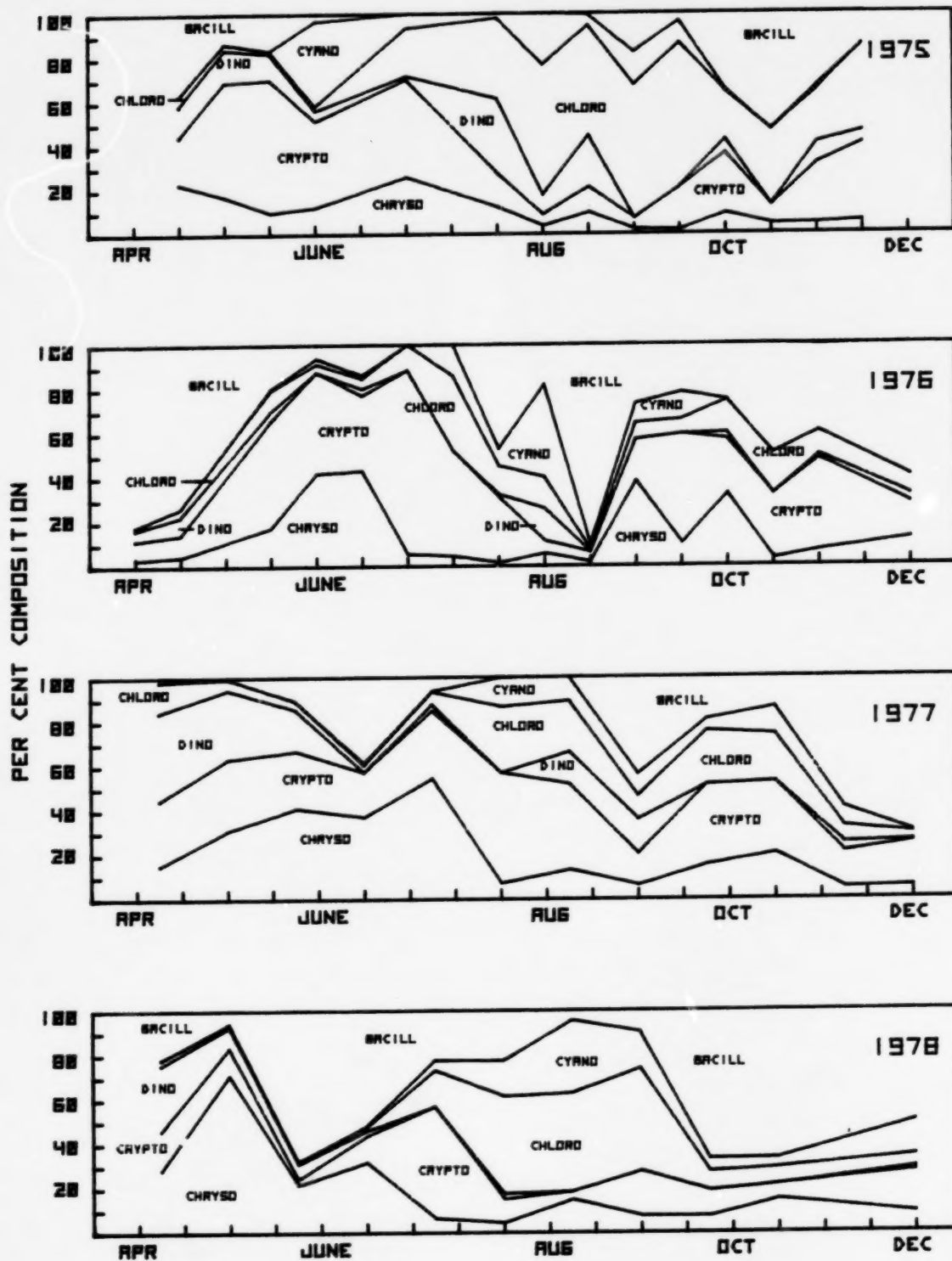


Figure 15:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 1008

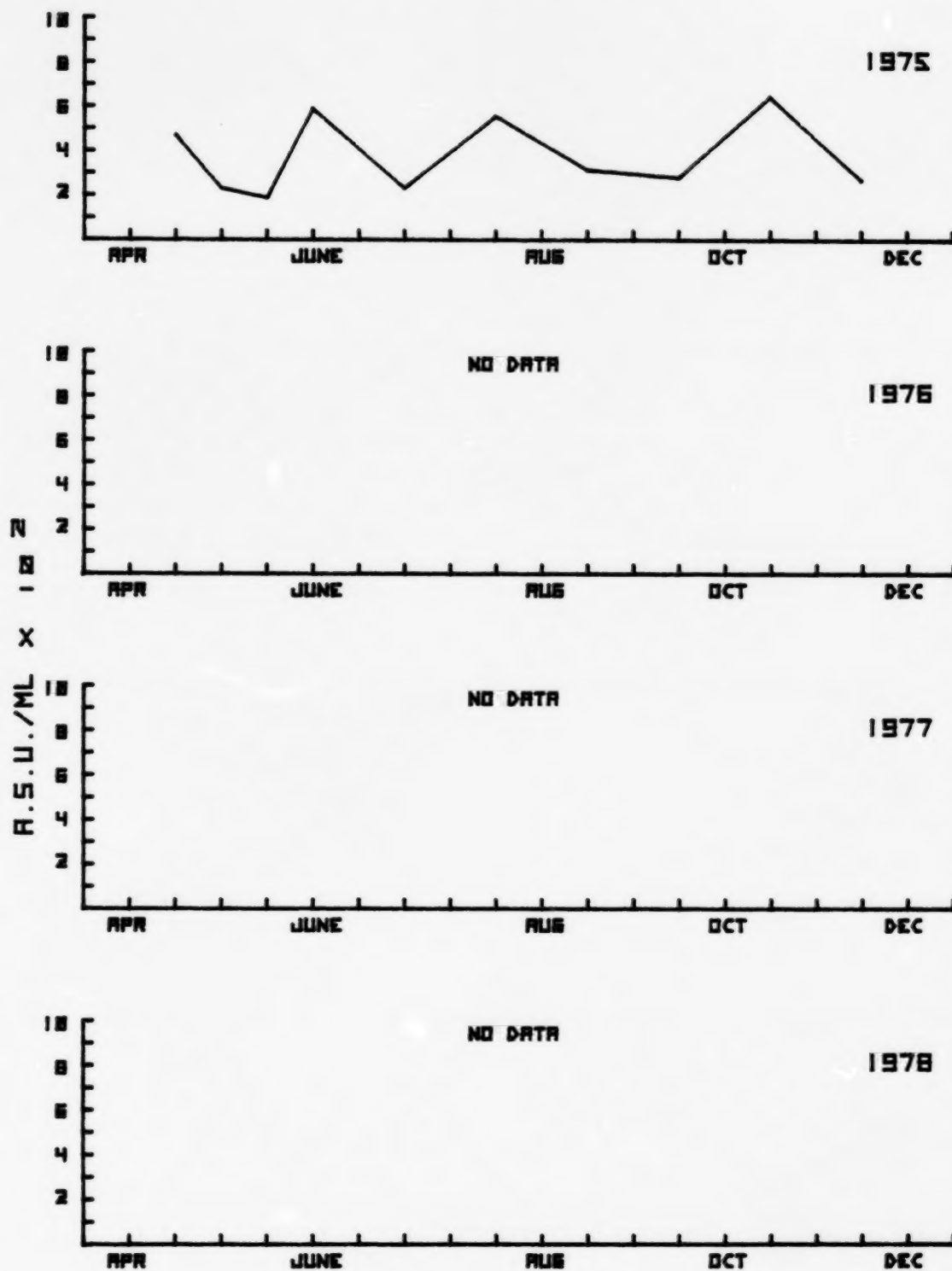


Figure 16:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 1016

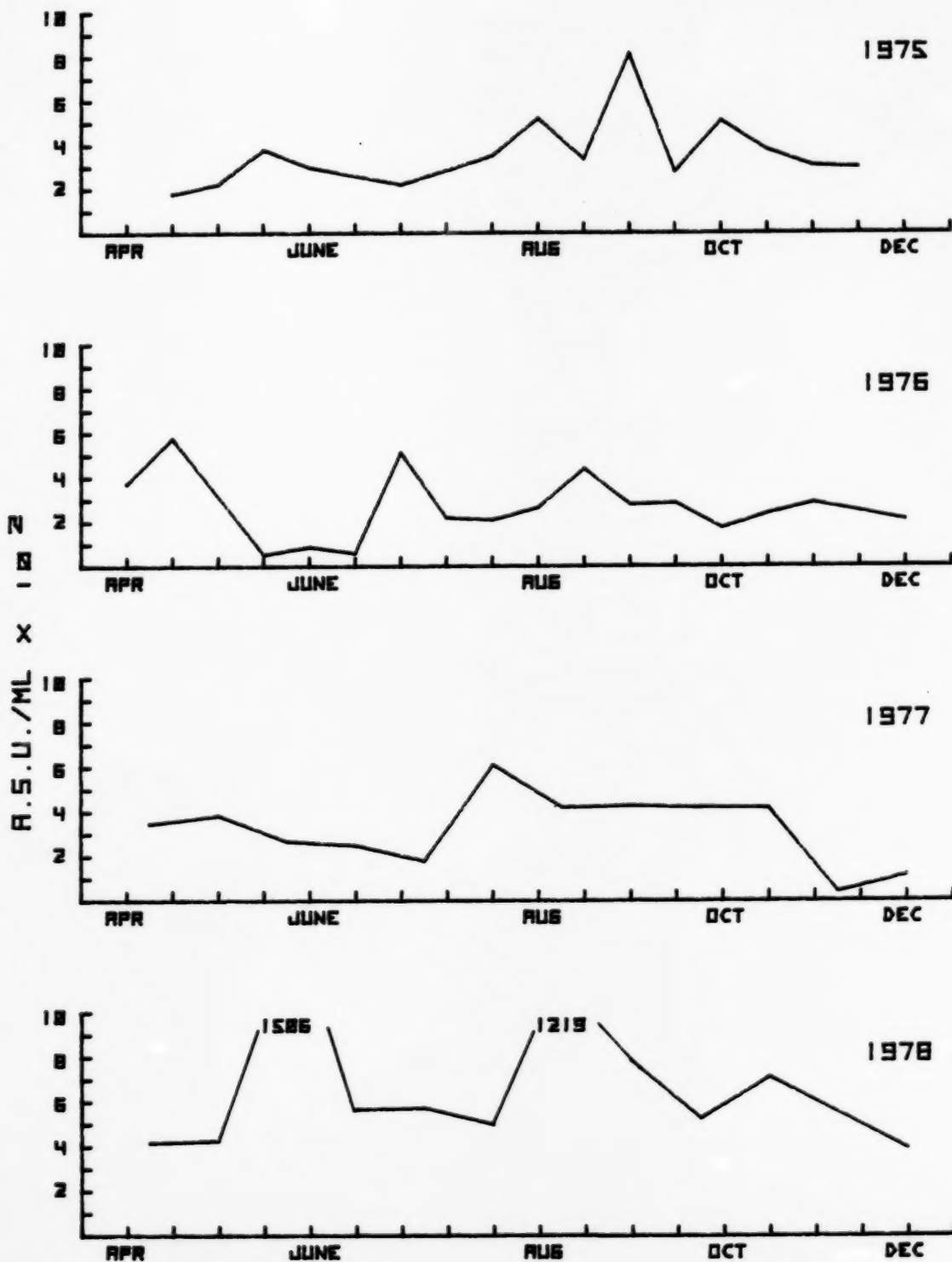


Figure 17:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 1016

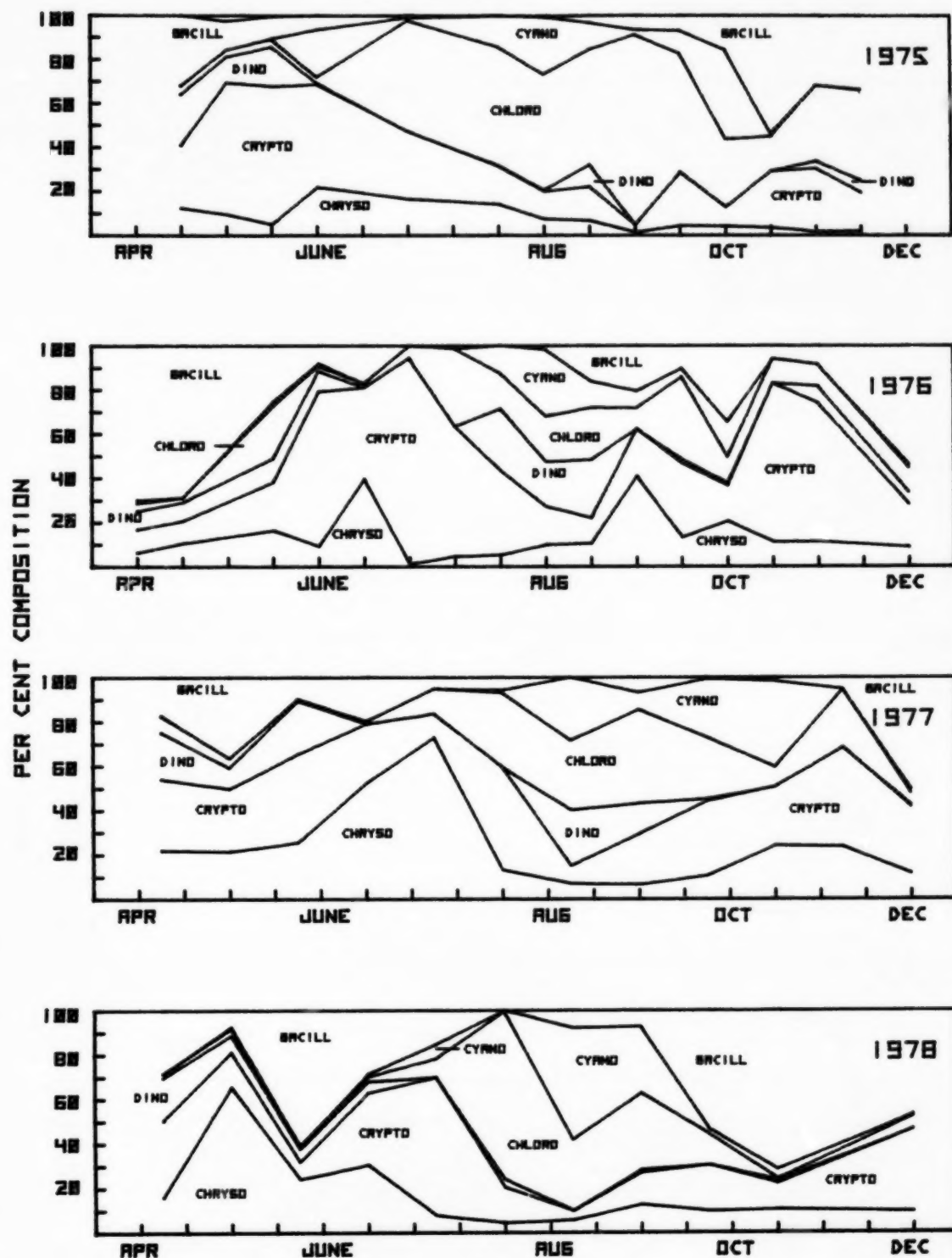


Figure 18:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 1040

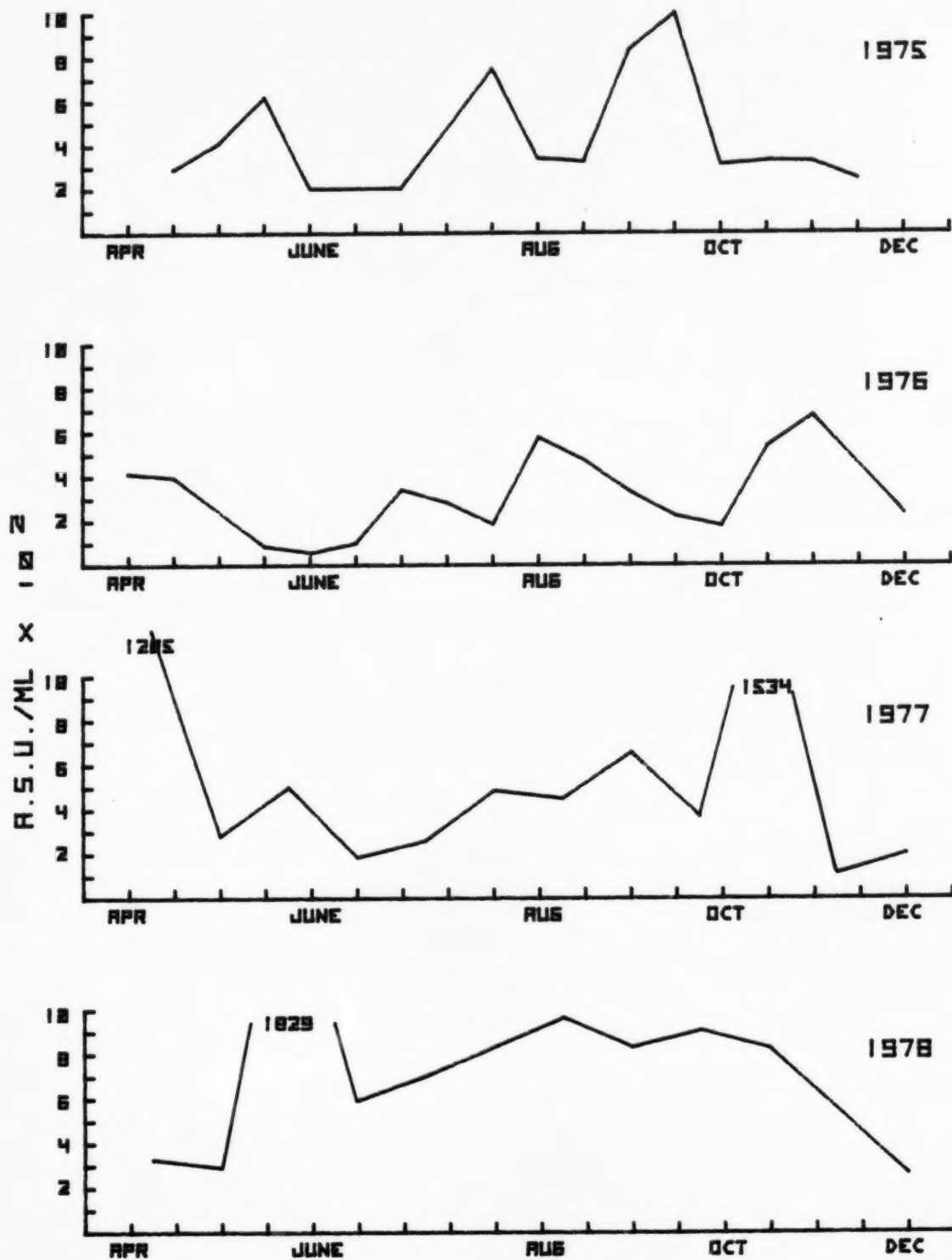


Figure 19:

NANTICKE PHYTOPLANKTON TOTAL BIOMASS STA. 1040

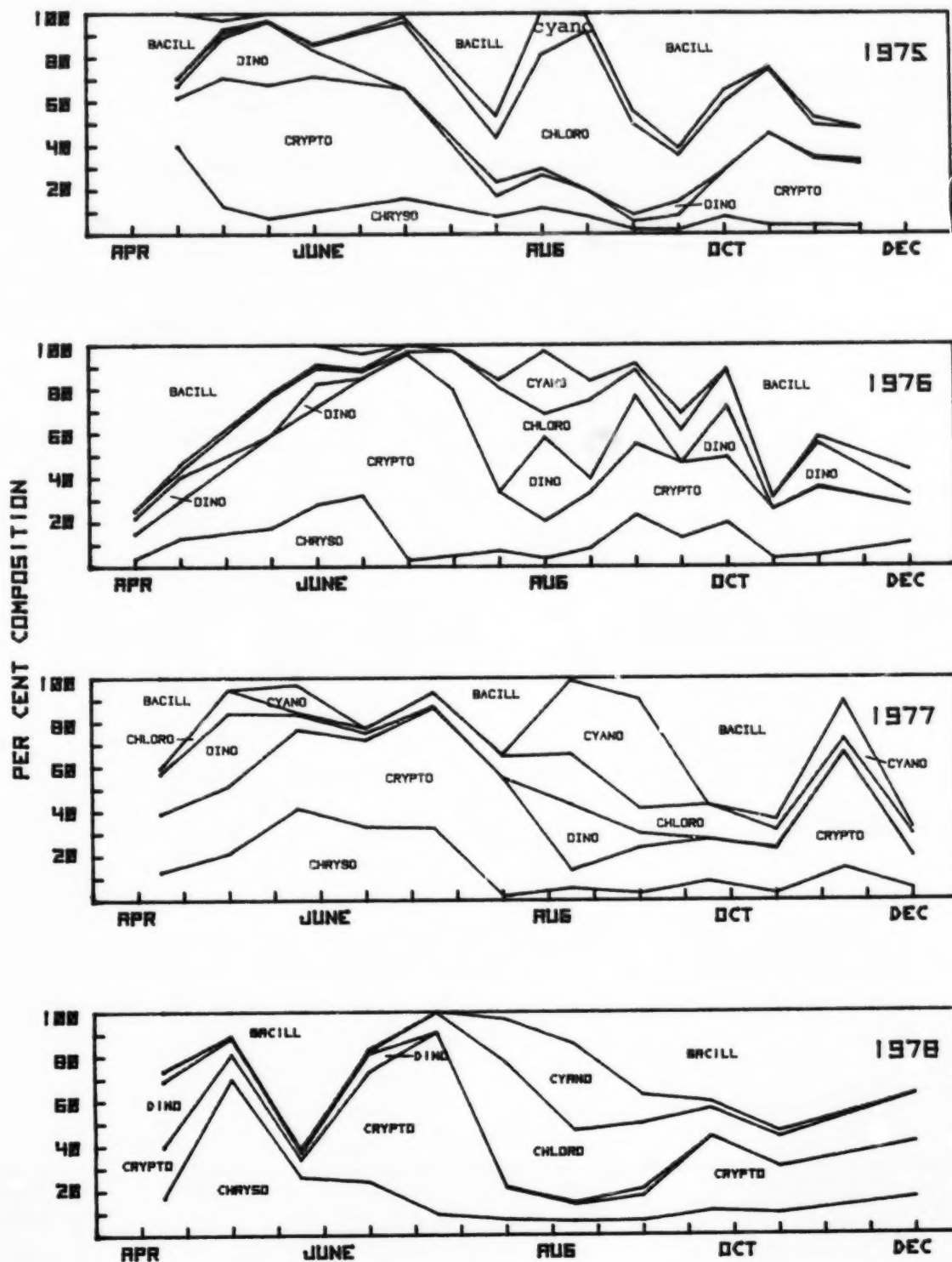


Figure 20:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 1041

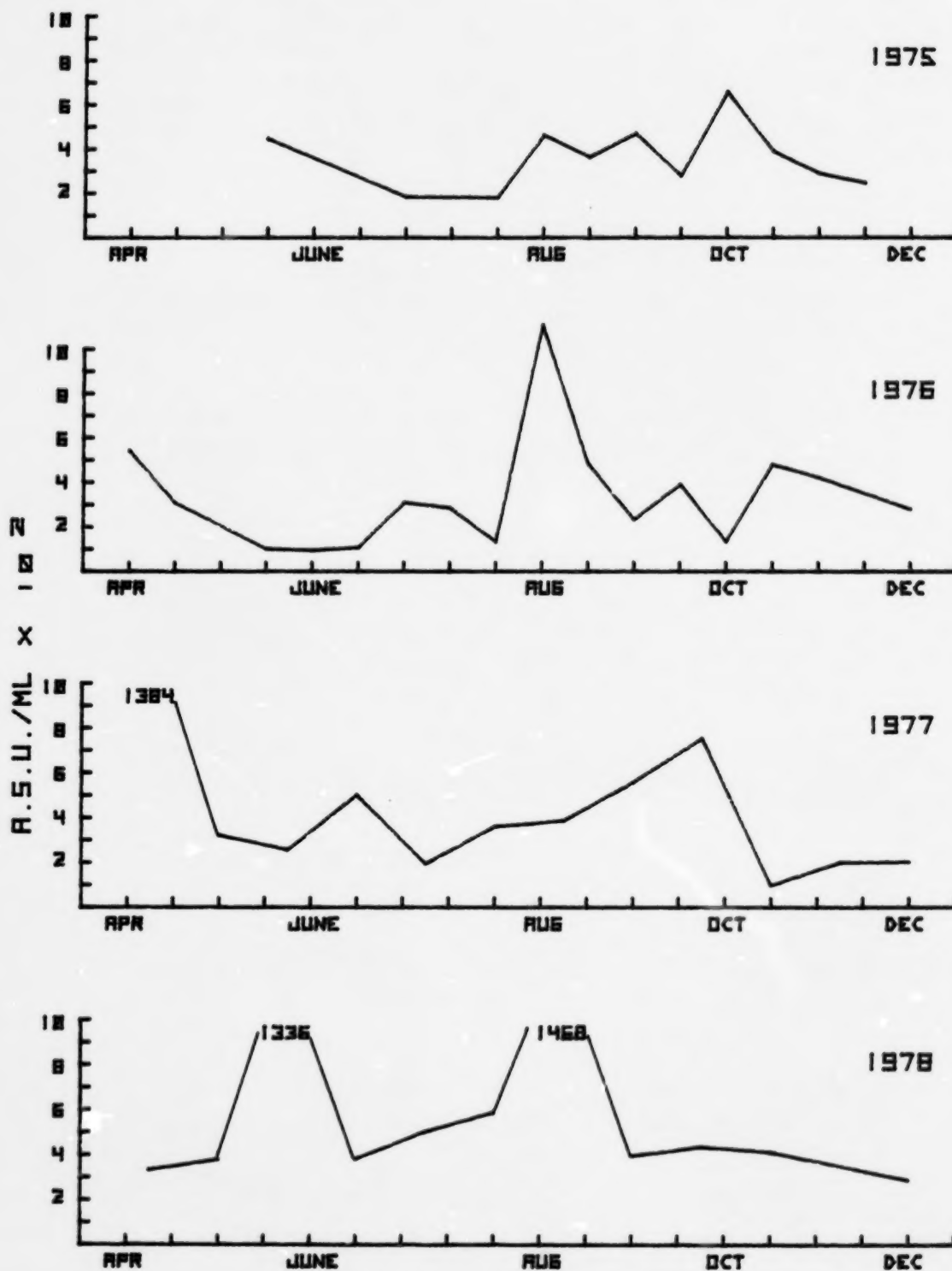


Figure 21:

NANTICKE PHYTOPLANKTON TOTAL BIOMASS STA. 1041

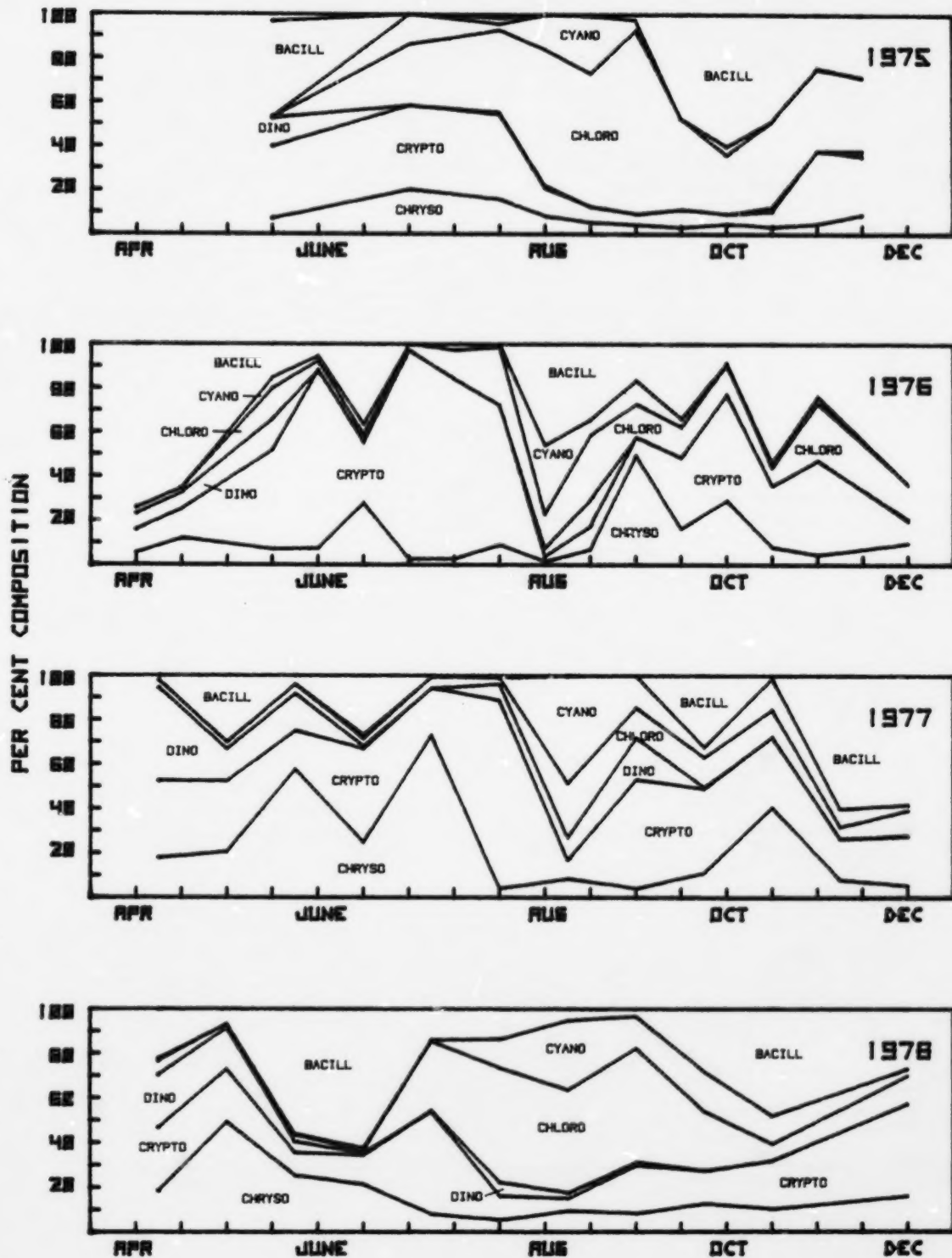


Figure 22:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 1042

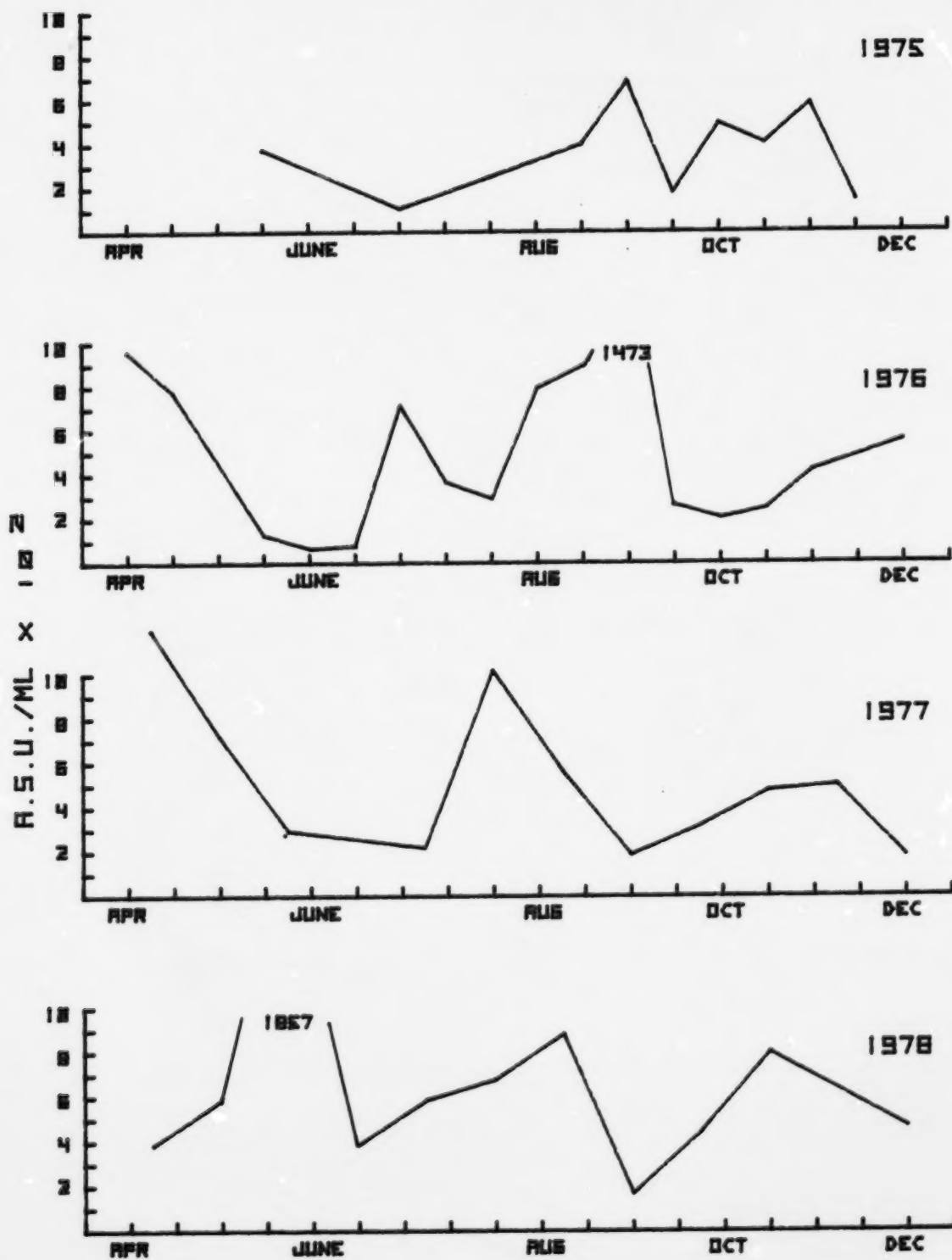


Figure 23:

NANTICKE PHYTOPLANKTON

TOTAL BIOMASS STA. 1042

